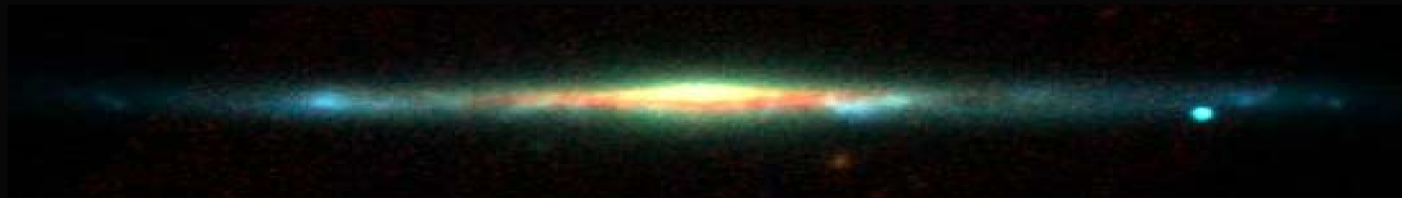

Dust Lanes: Why You Should Care

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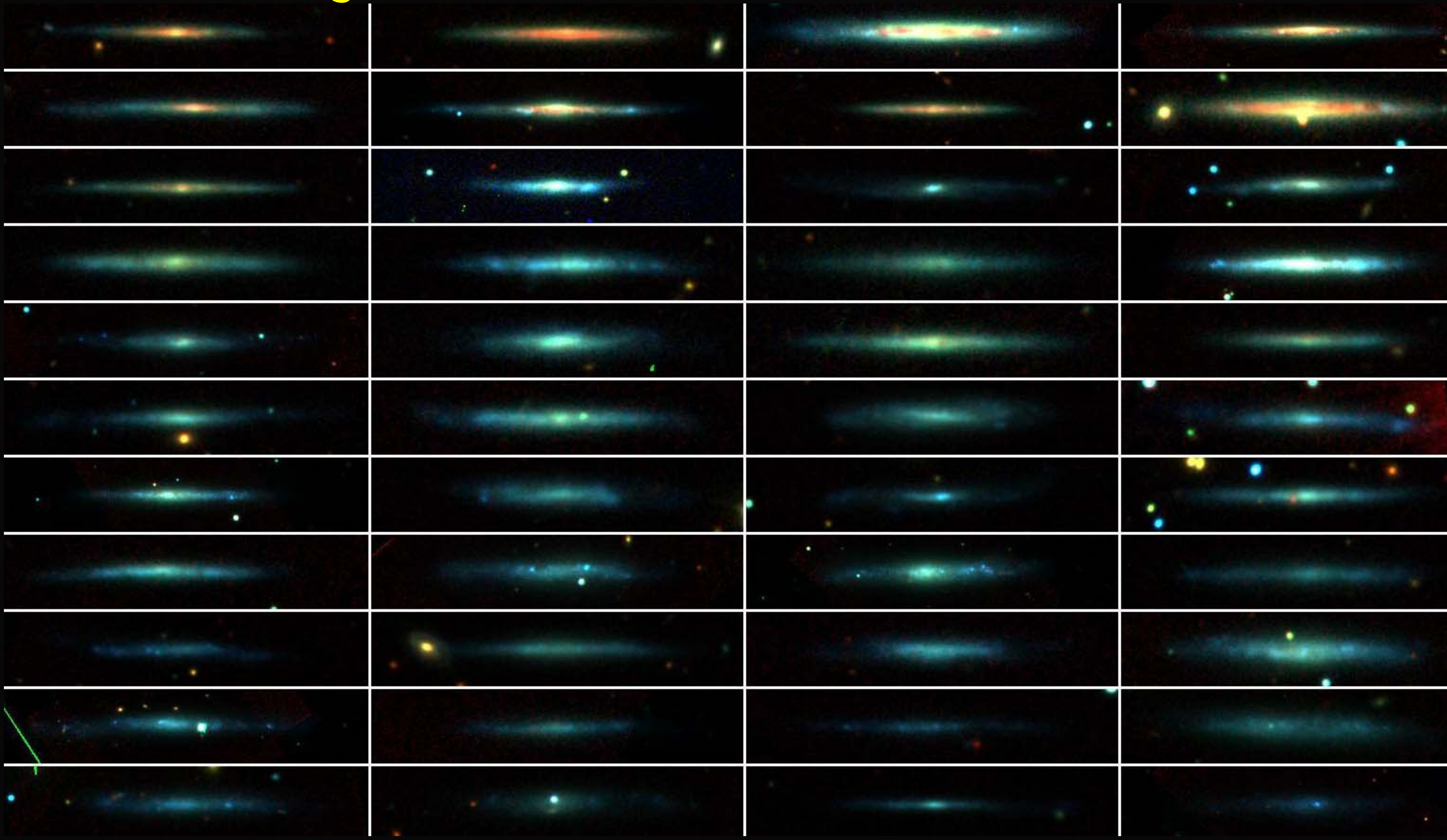
University of Washington

Collaborators:
Peter Yoachim (University of Washington)
Rebecca Bernstein (University of Michigan)

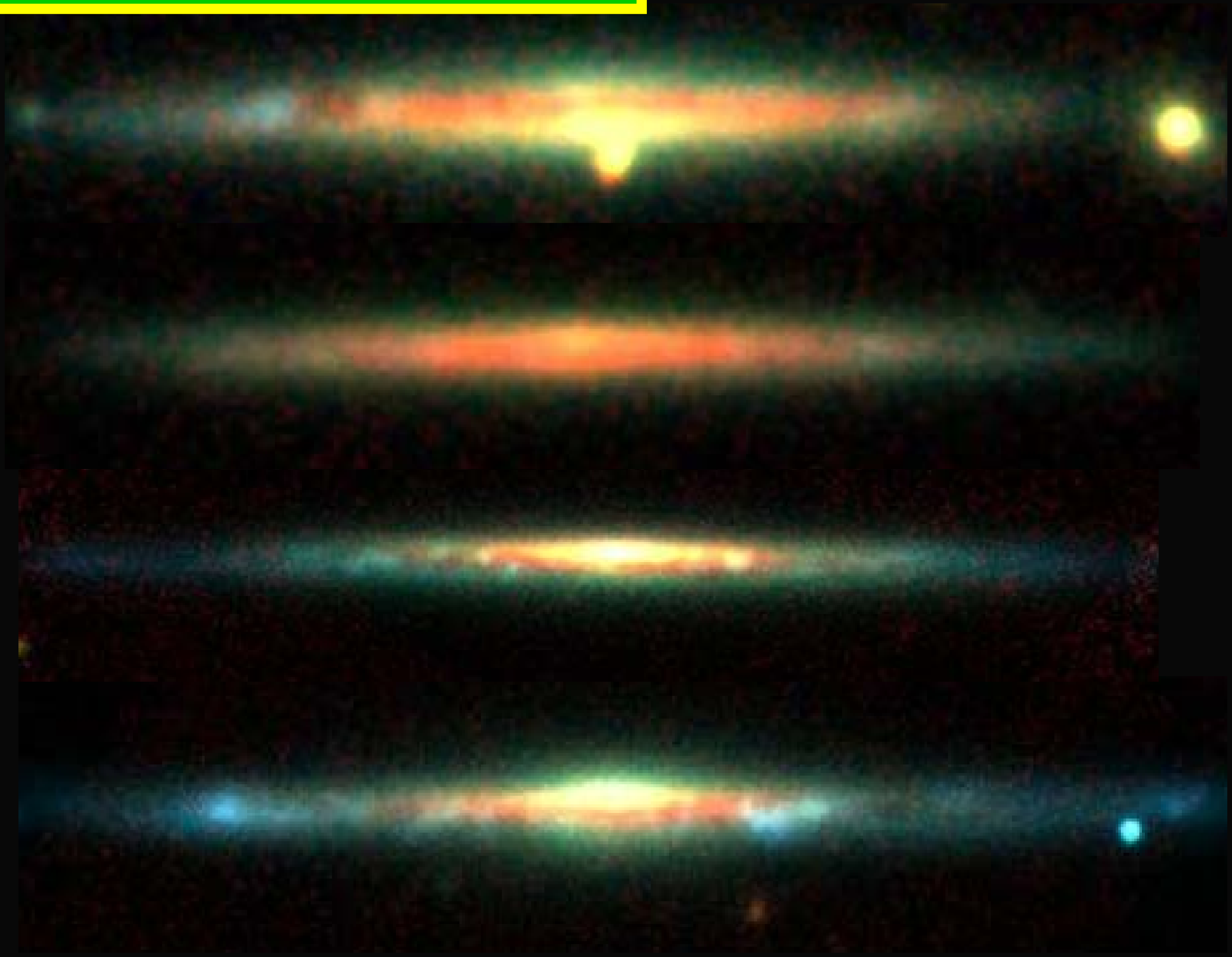
B, R, & K_s images of 48 bulgeless galaxies:



Dalcanton & Bernstein 2000,2002

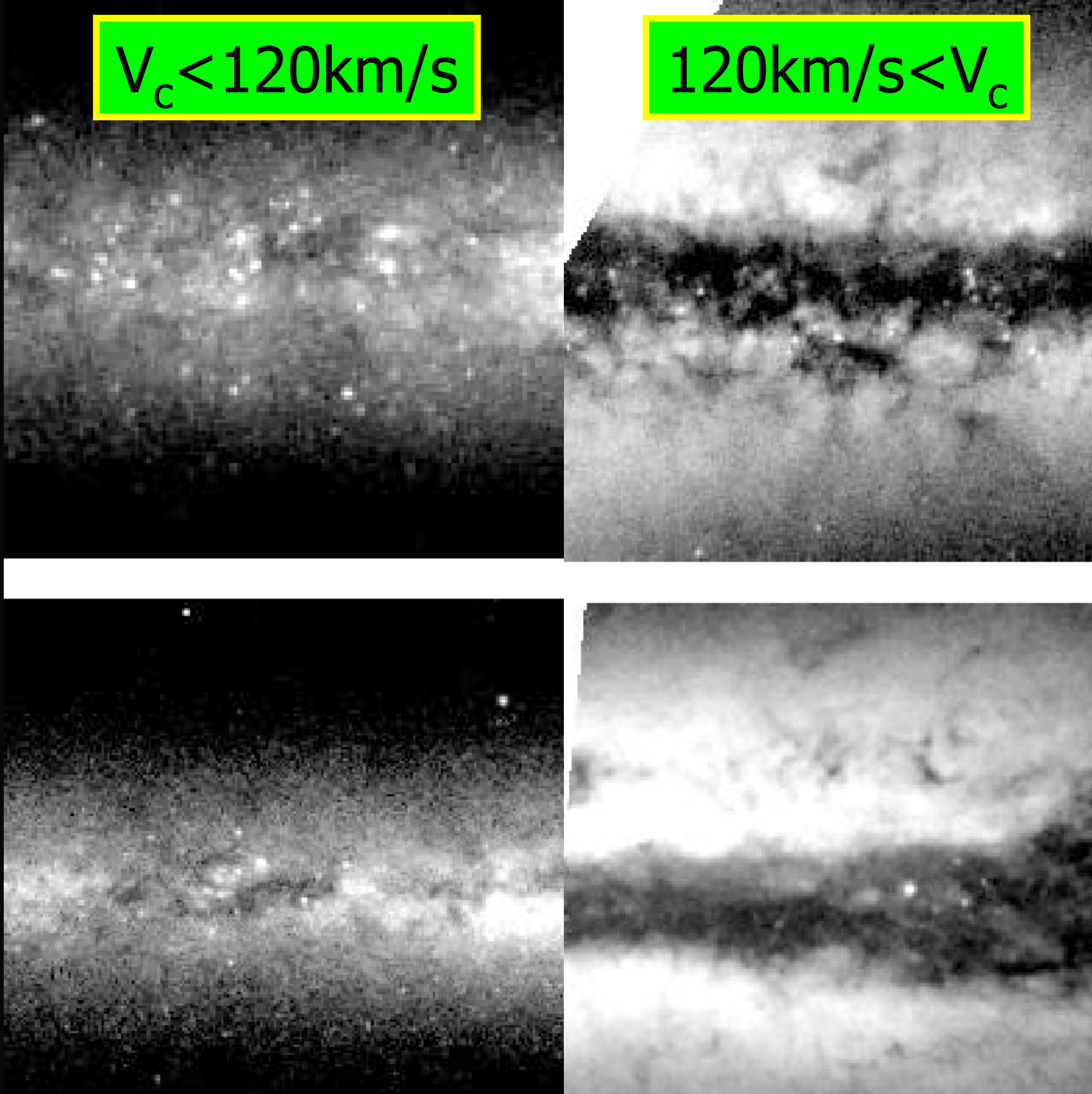
V_c = 35-250 km/s

$V_C > 120$ km/s



120 km/s ≥ V_c

Low mass galaxies have dust, but the scale height is **larger**.

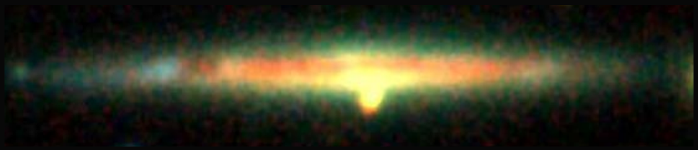


HST, Scaled to common distance

Dust Traces Gas:

High extinction regions trace CO

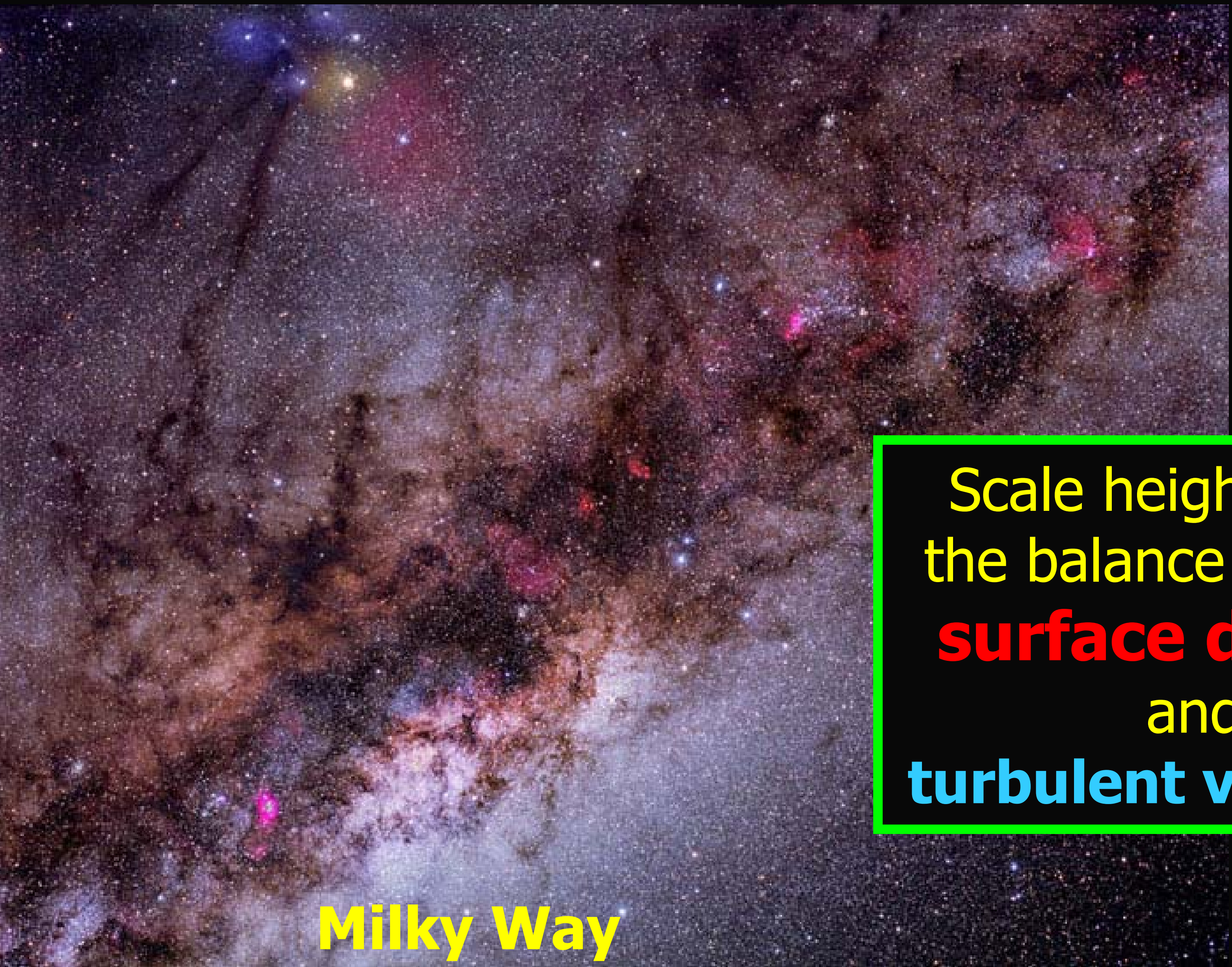
V_c>120 km/s: **Thin** layer of molecular gas



V_c<120 km/s: **Thick** layer of molecular gas

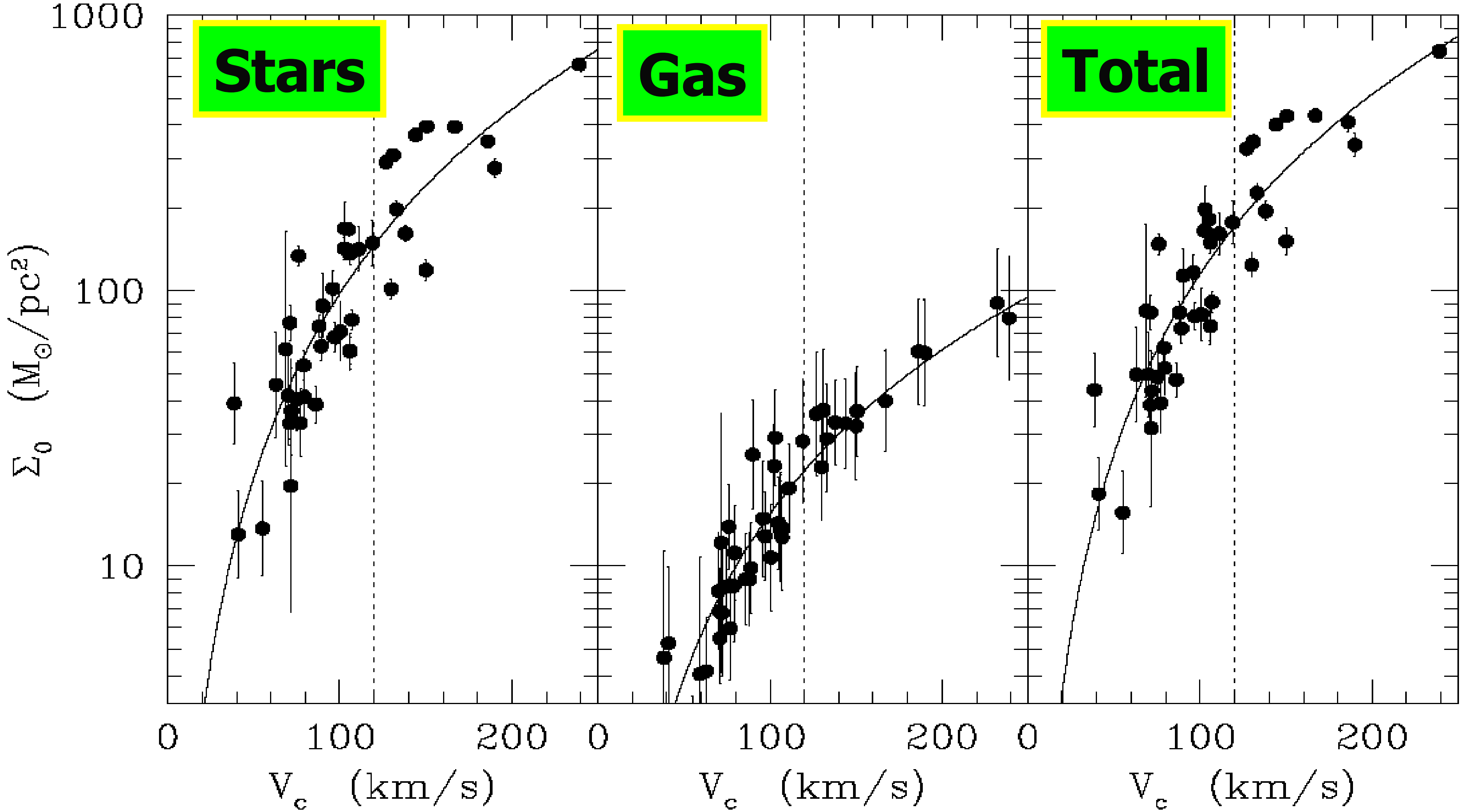
What sets the scale height of the cold ISM?

Turbulence supports the Cold ISM



Scale height set by the balance between **surface density** and **turbulent velocities**

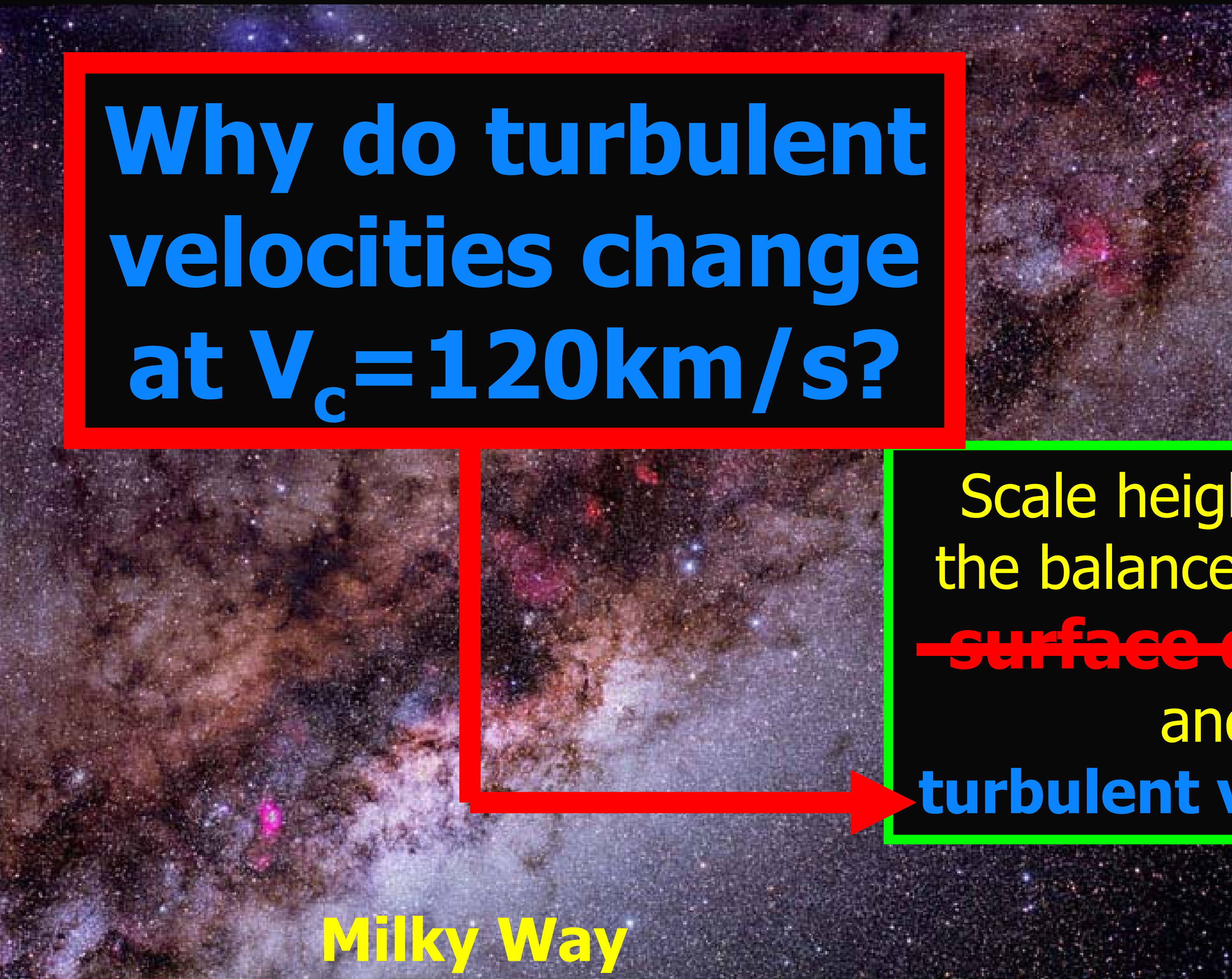
But, surface densities are comparable above and below 120 km/s



Derived from K-band fits, HI data, & correction for H_2.

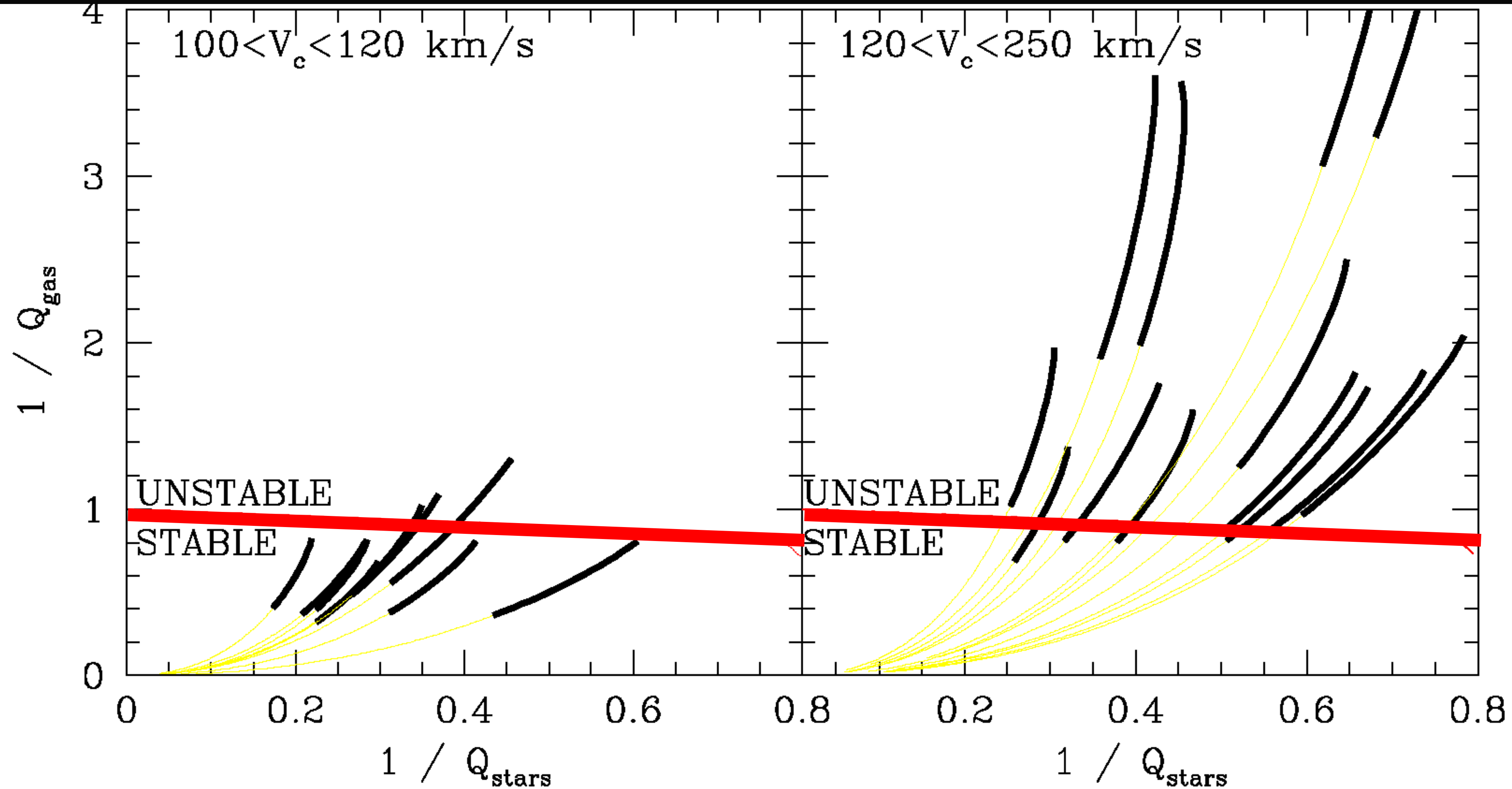
Turbulence supports the Cold ISM

Why do turbulent velocities change at V_c=120km/s?



Scale height set by the balance between ~~**surface density**~~ and **turbulent velocities**

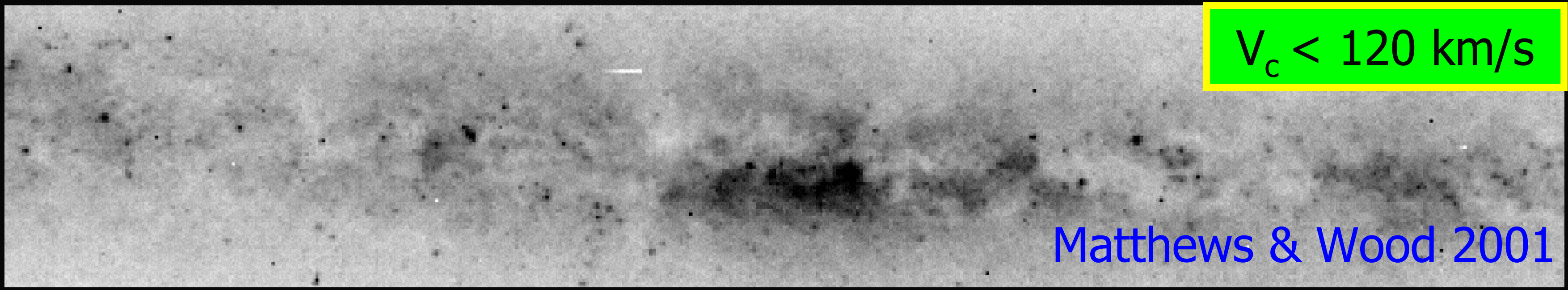
Massive disks (V_c > 120 km/s) are **gravitationally unstable**:



- Each line traces the stability **within** a galaxy.
- Black line is the **inner** region ($r < h_r$)

When disks are **unstable**:

- Low velocity turbulence is driven by **gravitational instabilities**.

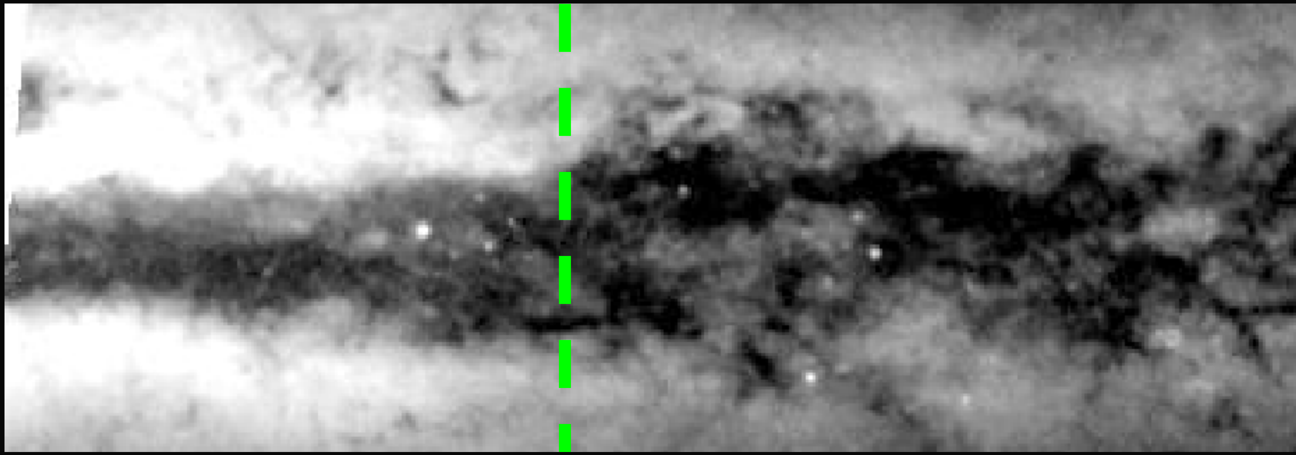


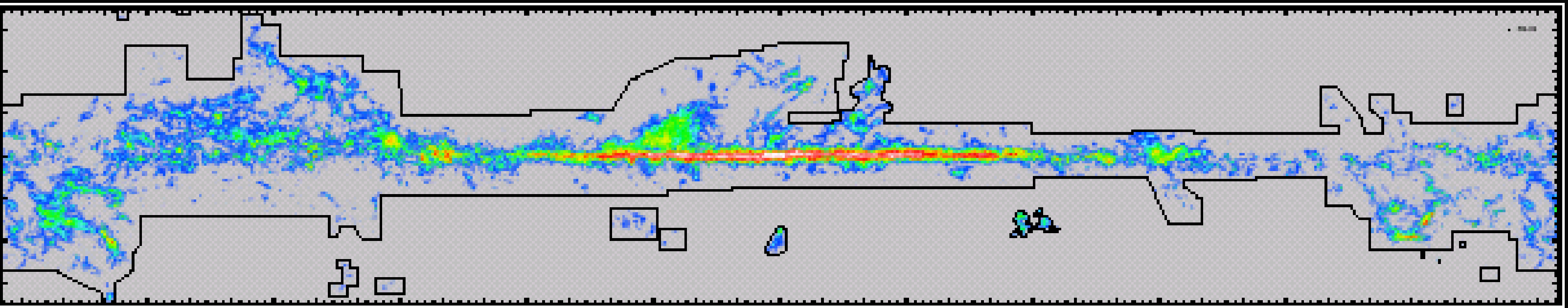
When disks are **stable**:

- High velocity turbulence is driven by **supernovae**.

Transition Exists within Individual Galaxies:

Outskirts of Galaxies are Stable



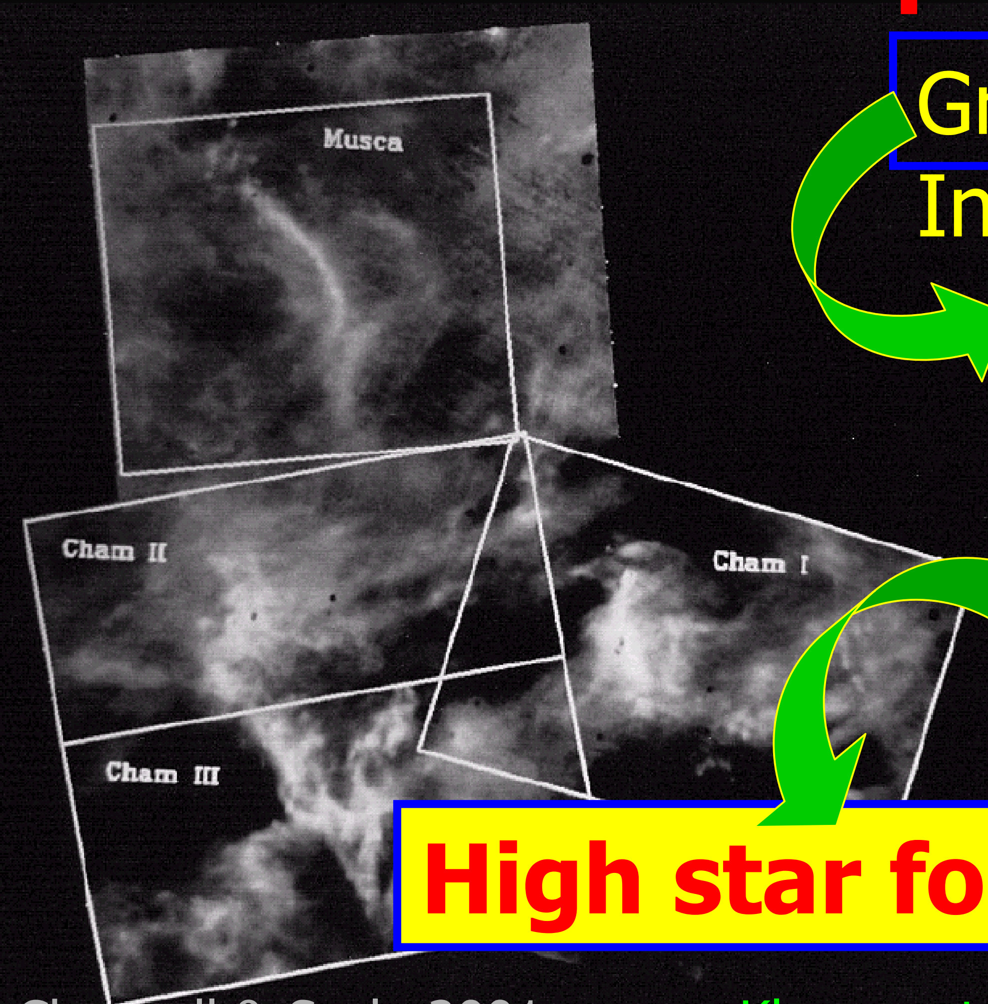


Structure of CO in the Milky Way changes sharply from the inner to outer Galaxy.

Explains the Kennicutt SF Threshold:

Turbulence regulates star formation

→ **Forms & Disrupts molecular clouds**



Gravitational Instabilities

Lower turbulent velocities

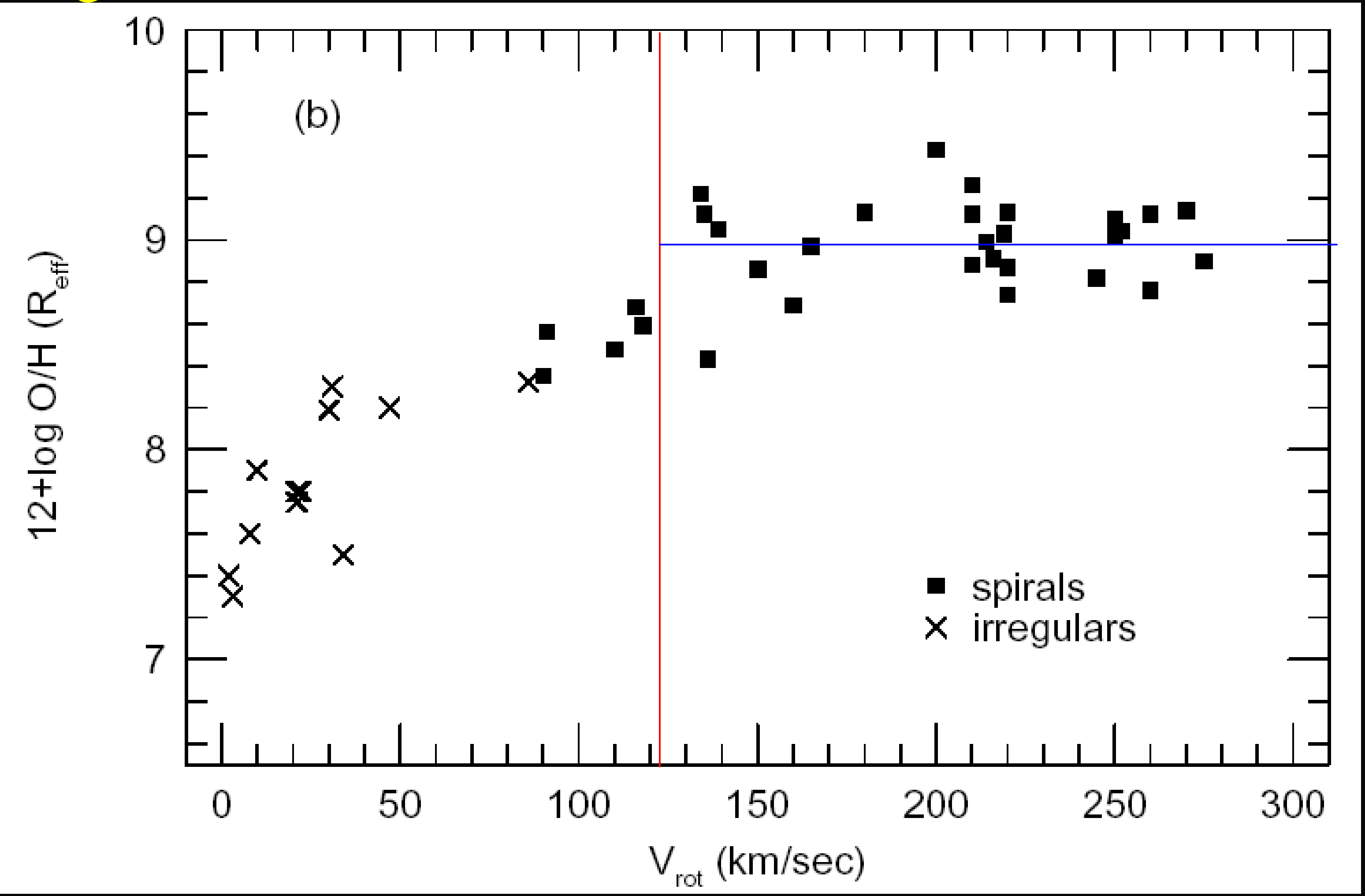
Larger, long-lived molecular clouds

High star formation efficiency

Chappell & Scalo 2001

Klessen et al 2000, Vazquez-Semadeni et al 2003

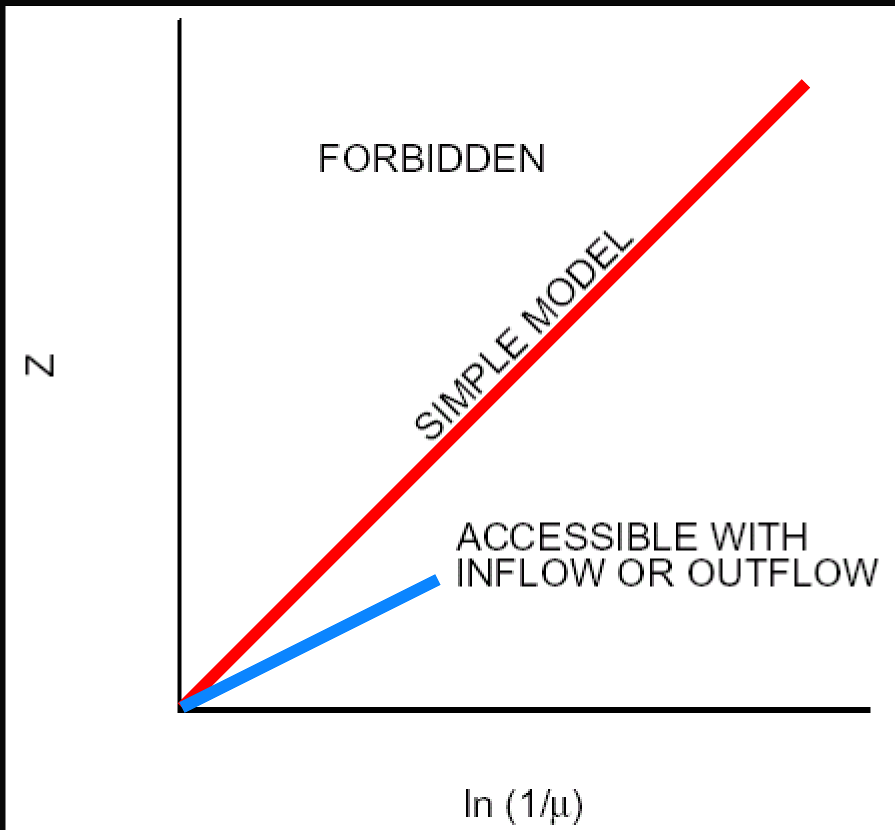
Reduced star formation efficiency for $V_c < 120$ km/s affects **metallicity**.



Garnett 2002

What sets the metallicity?

Increasing Metallicity →



Decreasing Gas Fraction →

Edmunds 1990

Closed Box Model

$$Z = y_Z \ln\left(\mu^{-1}\right)$$

Nucleosynthetic "yield"

$$y_{\rm eff} = \frac{Z(\rm obs)}{\ln\left(\mu^{-1}\right)}$$

"Effective Yield"

Two regimes have different yields

Unstable Disks: ($V_c > 120$ km/s)

- Star Formation is highly efficient
- Infall is immediately converted to stars.
- "Balanced infall"
- Predicts constant yield.

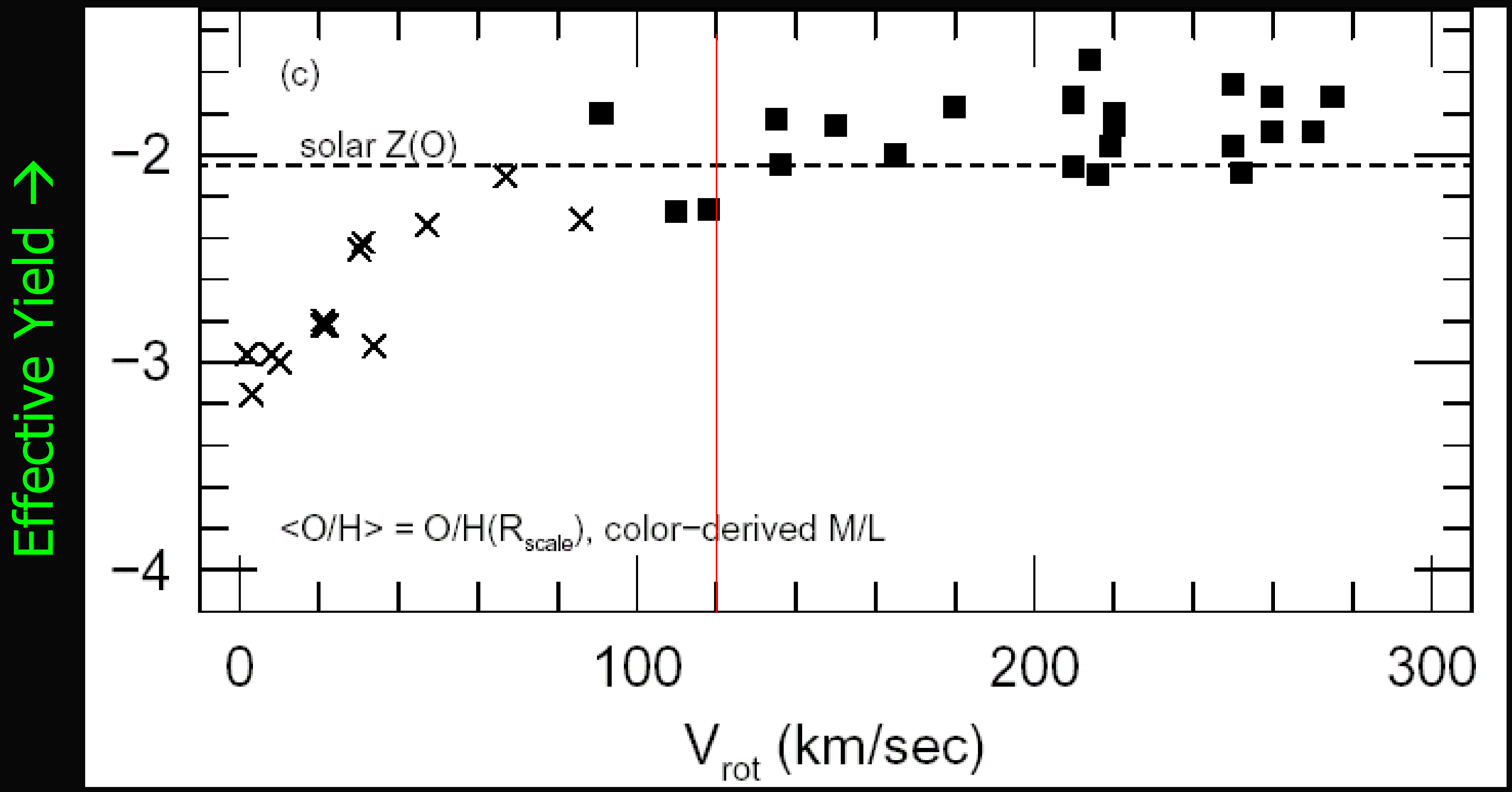
Elmegreen 2002

Stable Disks: ($V_c < 120$ km/s)

- Star formation inefficient.
- Infall builds up and dilutes gas supply.
- Yield is reduced.

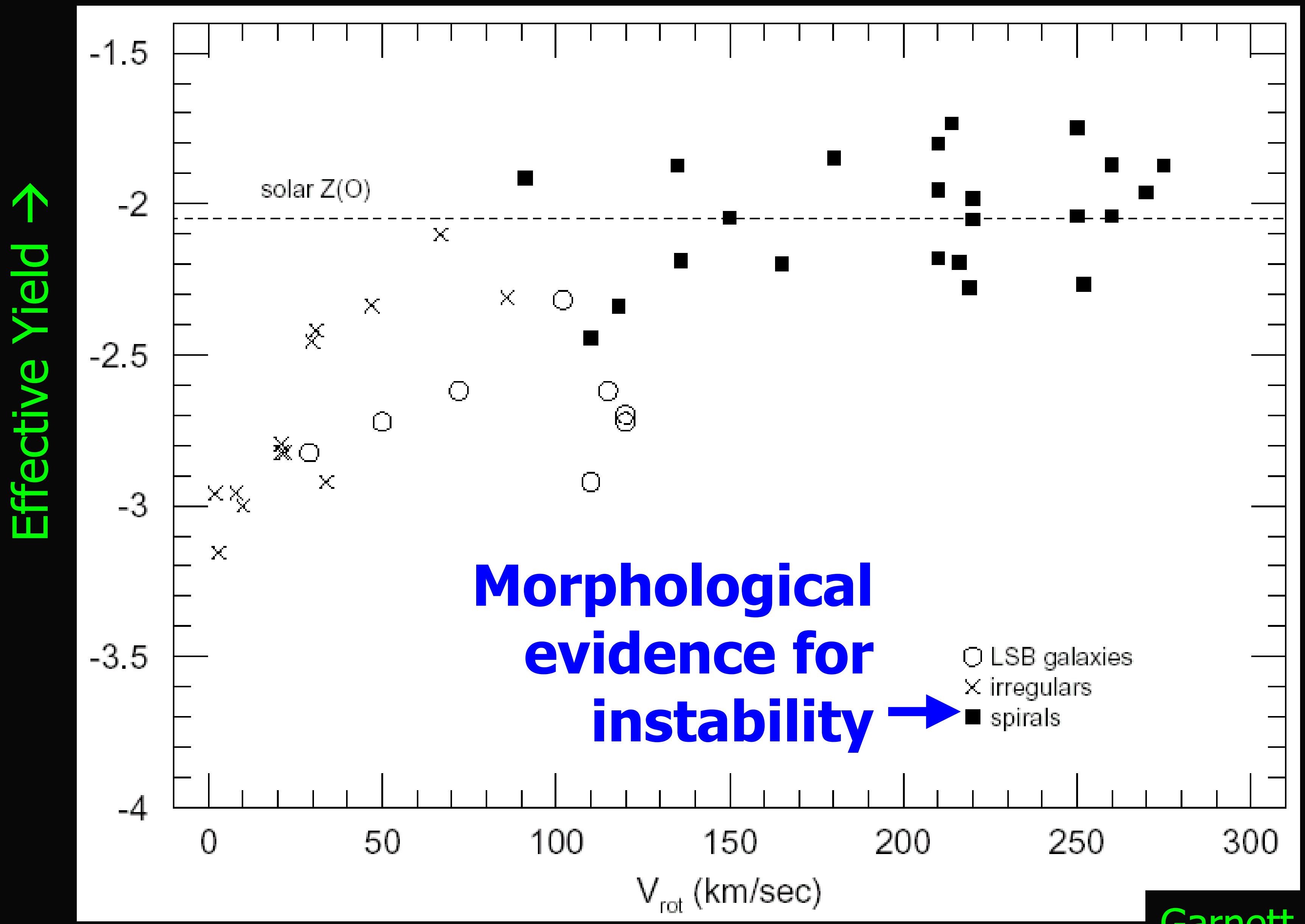
Koppen & Edmunds 1999

Effective yield is constant for V > 120 km/s



Garnett 2002

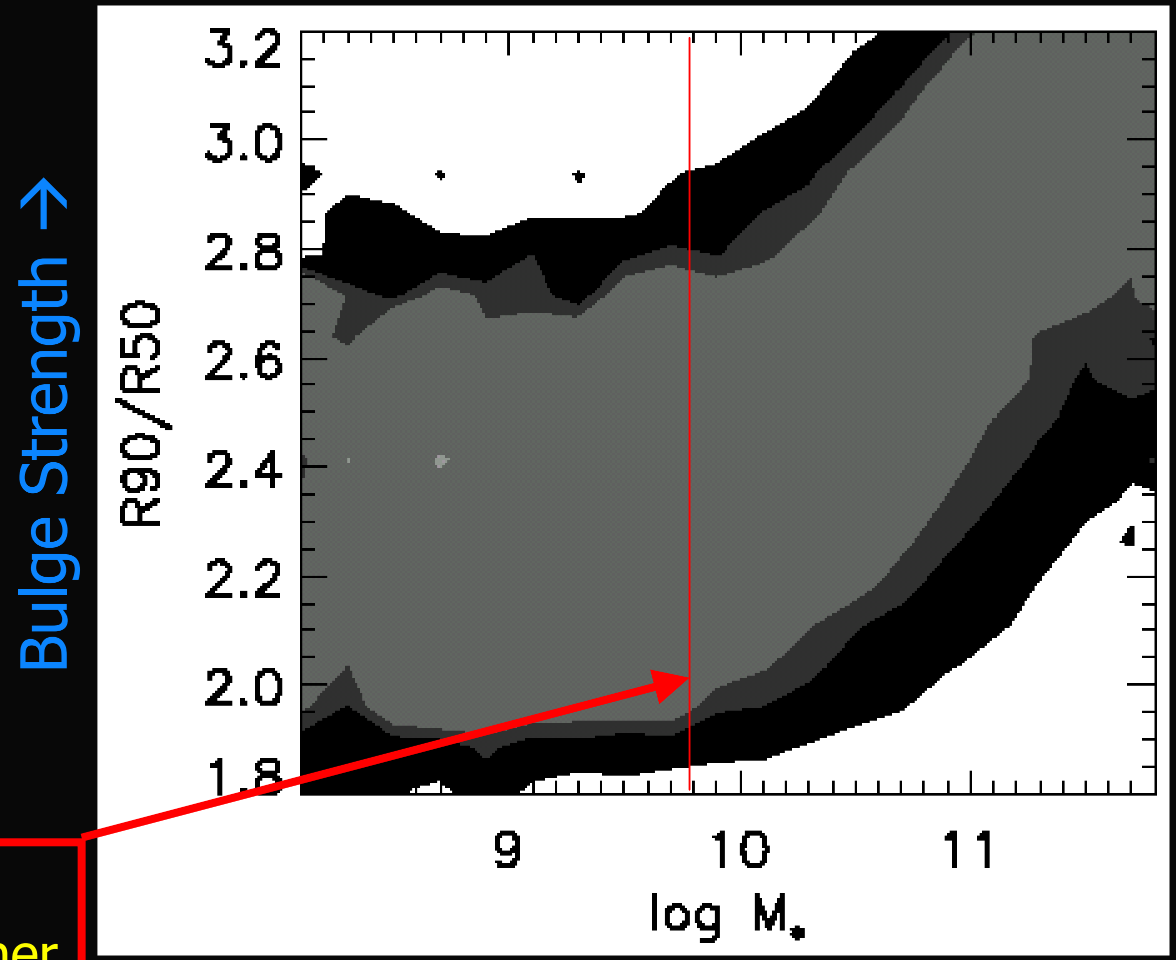
Effective yield constant for **spirals**



Garnett 2002

Disk stability at V_c<120 km/s also may explain lack of bulges:

Secular bulge formation effective only for V_c>120 km/s

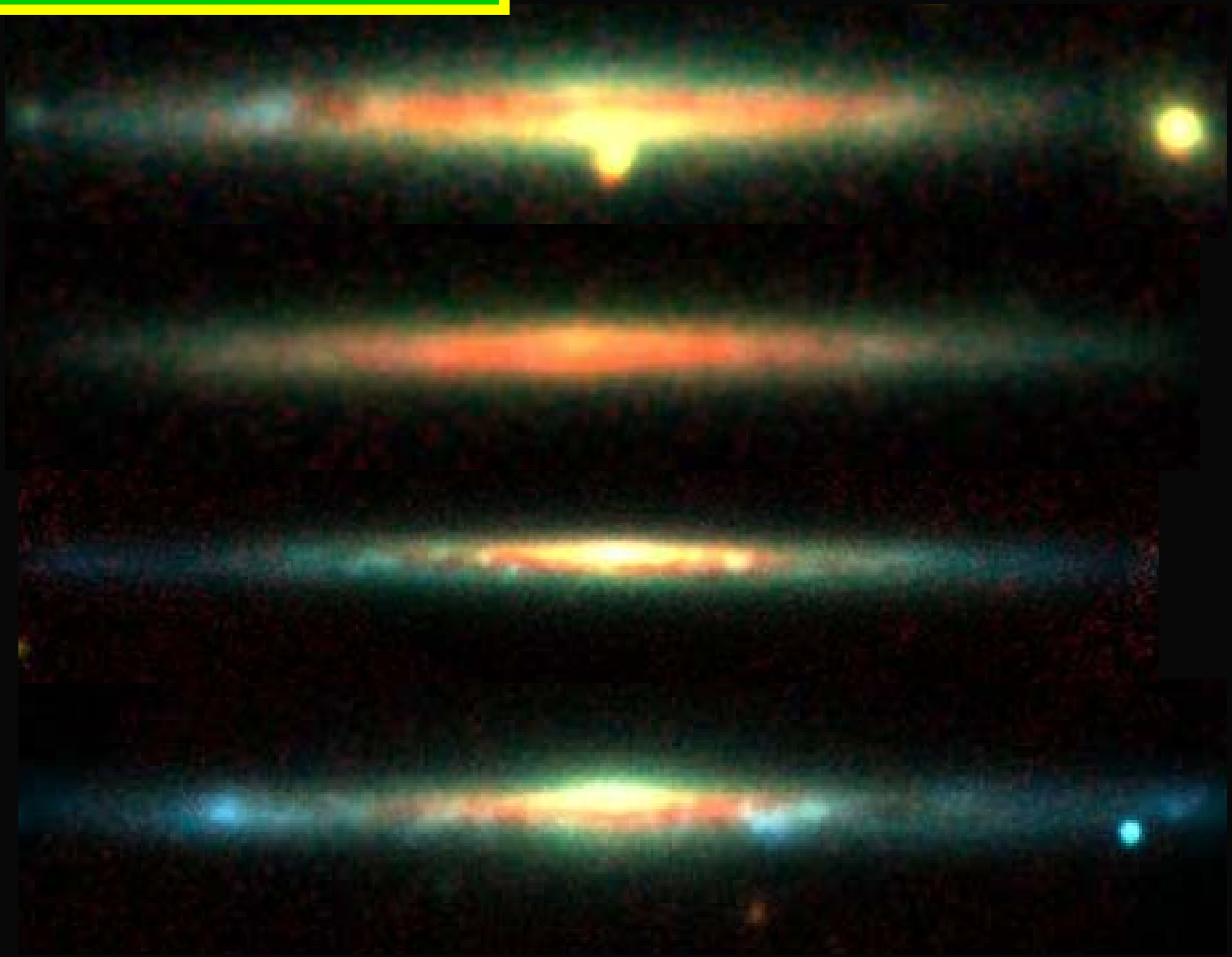


V_c = 120 km/s for baryonic Tully-Fisher relation of Bell & de Jong 2001

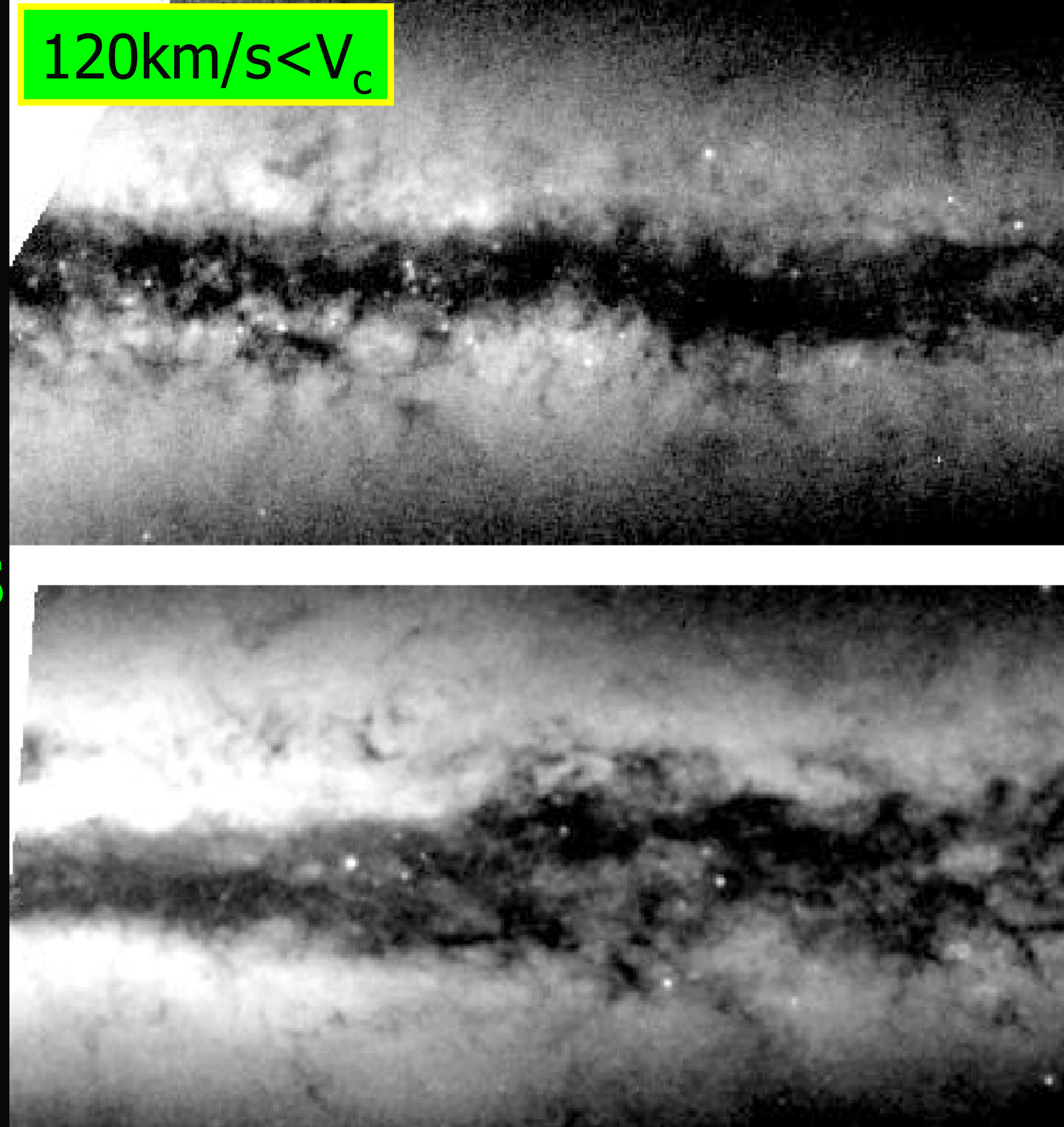
SDSS: Kauffmann et al 2002

$V_C > 120$ km/s

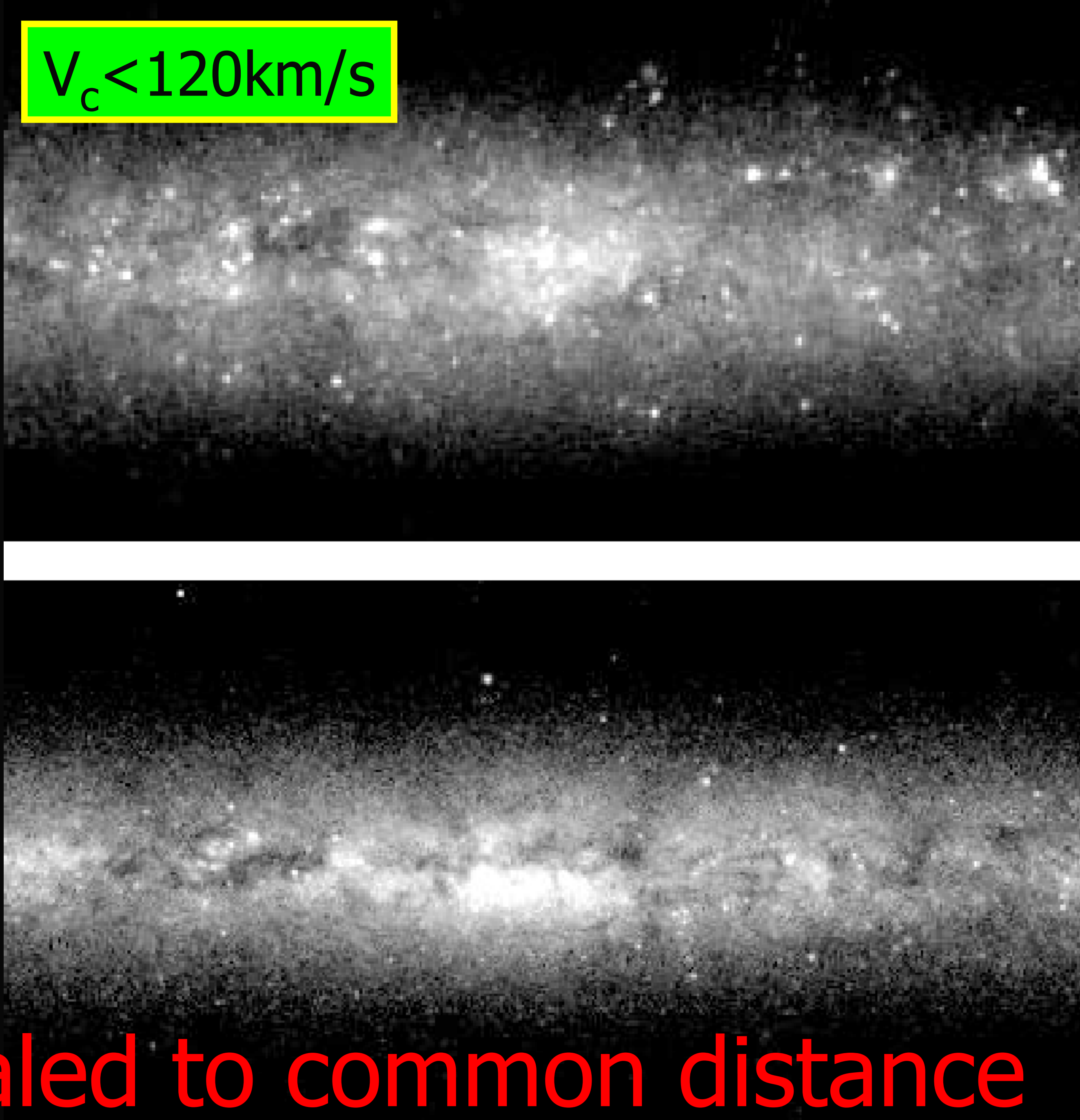
3-d Bulges



Star formation concentrates within the dust lane:



HST

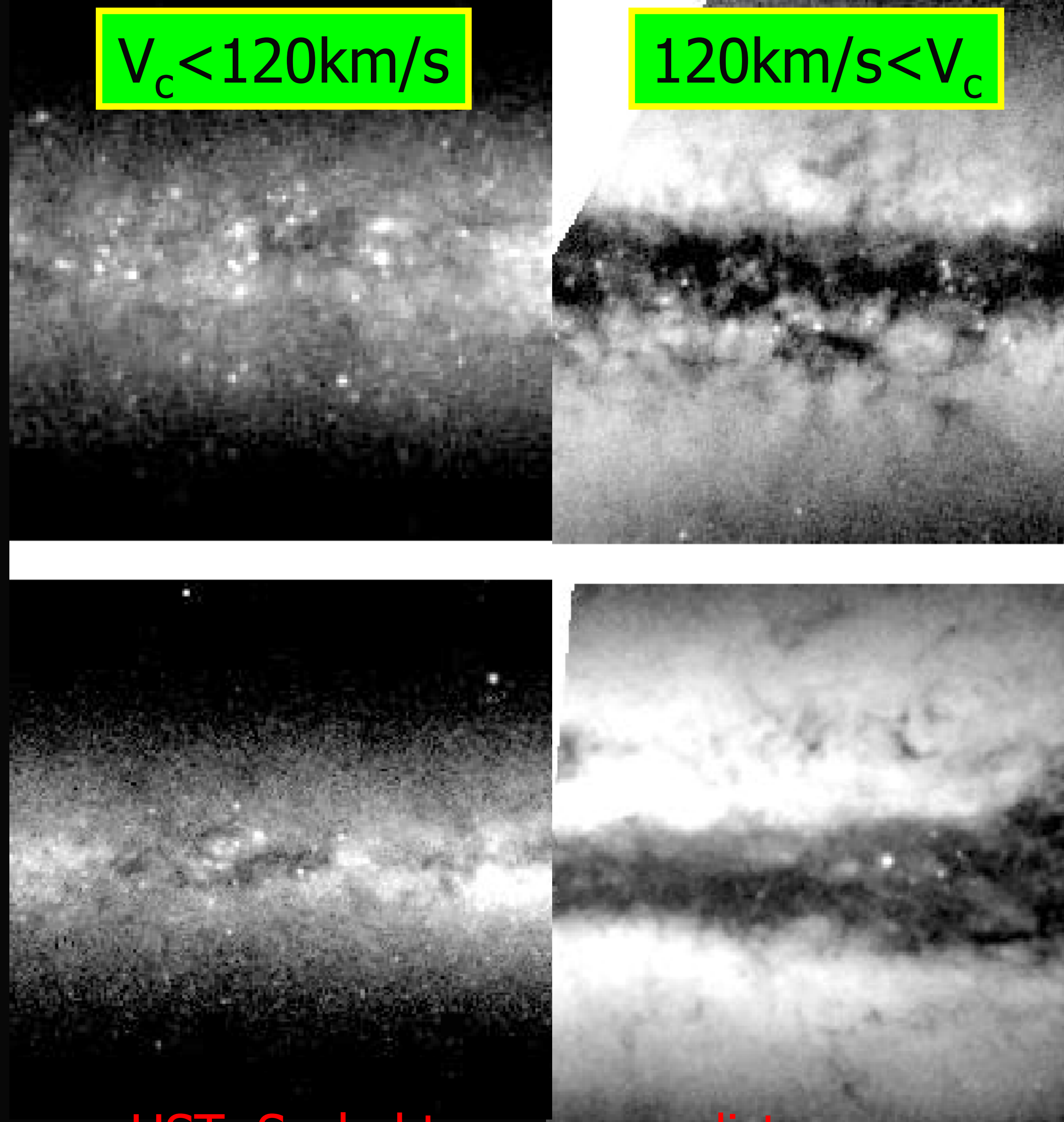


Star formation has a much larger scale height.

HST, Scaled to common distance

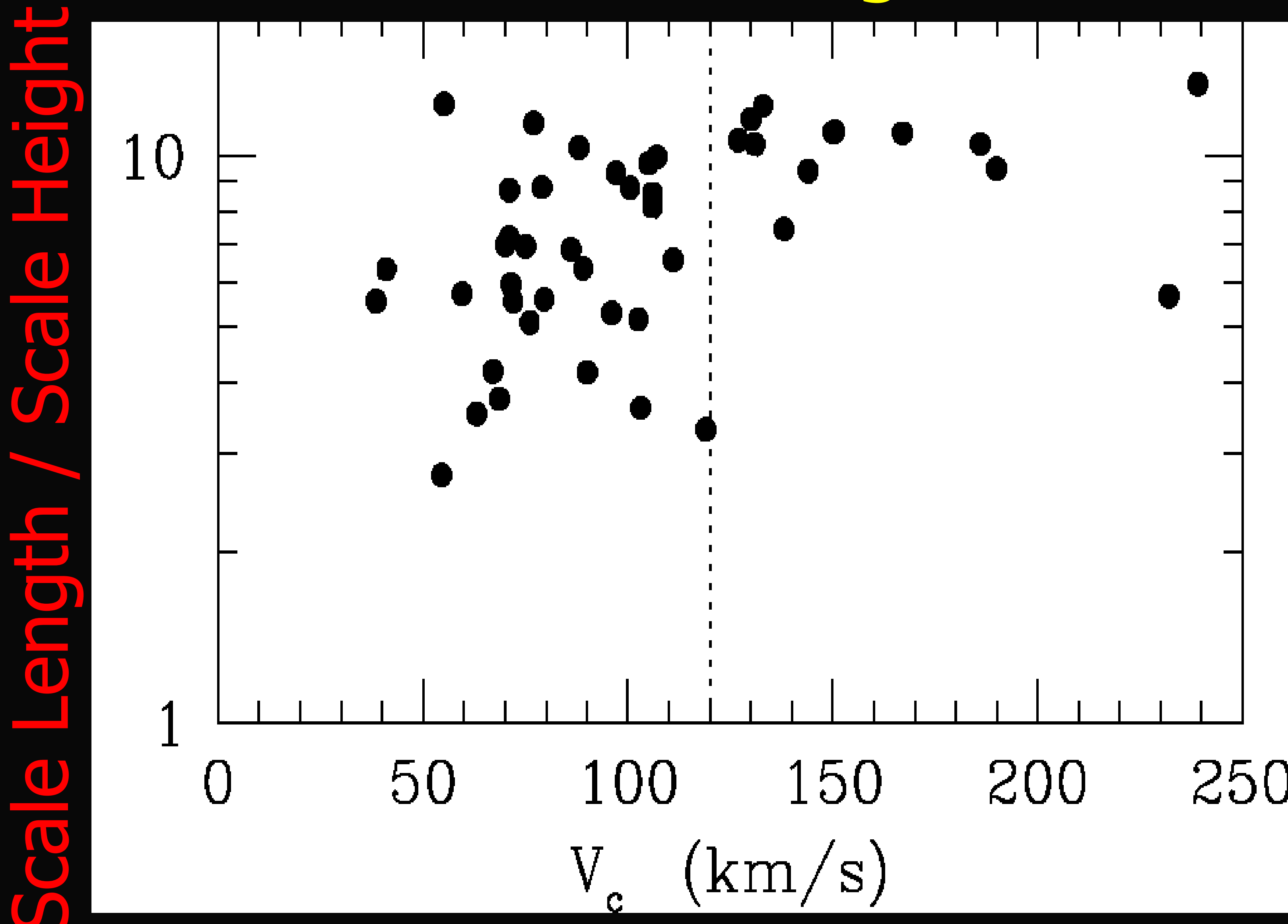
Young stars trace the cold ISM:

Young stellar disk is thicker in low mass galaxies



HST, Scaled to common distance

Explains thickness of dwarf galaxies:



Conclusions:

- Disks become unstable at V_c >120 km/s
- Gravitational instabilities drive turbulence with lower rms velocities than SN-drive turbulence.
- Numerical simulations show that star formation is highly efficient when turbulent velocities are low. Explains the Kennicutt SF law.
- Inefficient star formation leads to reduced nucleosynthetic yields, explaining metallicities.
- Disk instabilities coupled to bulge formation.
- Thicker cold ISM in low mass disks explains thickness of dwarf galaxies.